L Number	Hits	Search Text	DB	Time stamp
1	9	(("3597549") or ("3647975") or ("6731002") or ("4063220") or ("4251880") or ("4400585") or ("5121387") or ("5124985") or ("5142533") or ("5276911")).PN.	USPAT	2004/01/13 06:11
2	7	(timeslot time-slot (time adj slot)) and ((("3597549") or ("3647975") or ("6731002") or ("4063220") or ("4251880") or ("4400585") or ("5121387") or ("5124985") or ("5142533") or ("5276911")).PN.)	USPAT	2004/01/13 06:20
3	7053	(timeslot time-slot (time adj slot)) with (assigning assigned assignment allocat$6)	USPAT	2004/01/13 06:20
4	414460	(timeslot time-slot (time adj slot)) ad6 (assigning assigned assignment allocat$6)	USPAT	2004/01/13 06:20
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6	4417	(timeslot time-slot (time adj slot)) adj5 (assigning assigned assignment allocat$6)	USPAT	2004/01/13 06:21
7	4019	(timeslot time-slot (time adj slot)) adj3 (assigning assigned assignment allocat$6)	USPAT	2004/01/13 06:21
8	3630	(timeslot time-slot (time adj slot)) adj2 (assigning assigned assignment allocat$6)	USPAT	2004/01/13 06:21
9	3141	(timeslot time-slot (time adj slot)) adj (assigning assigned assignment allocat$6)	USPAT	2004/01/13 06:21
10	2311	(timeslot time-slot (time adj slot)) adj (assigning assigned assignment assign)	USPAT	2004/01/13 06:48
11	1258	((timeslot time-slot (time adj slot)) adj (assigning assigned assignment assign)) and @pd<=19971231	USPAT	2004/01/13 10:17
12	1036	((timeslot time-slot (time adj slot)) adj (assigning assigned assignment assign)) and @pd<=19951231	USPAT	2004/01/13 06:22
13	858	((timeslot time-slot (time adj slot)) adj (assigning assigned assignment assign)) and @pd<=19931231	USPAT	2004/01/13 06:23
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15	81	((timeslot time-slot (time adj slot)) adj (assigning assigned assignment assign)) and @pd<=19931231 and 370/$5.ccls. and optic$5	USPAT	2004/01/13 06:24
16	81	(("5243598") or ("5237563") or ("5223968") or ("5208808") or ("5200955") or ("5197064") or ("5195091") or ("5195090") or ("5189673") or ("5184347") or ("5179552") or ("5175537") or ("5166926") or ("5157654") or ("5142527") or ("5130984") or ("5124978") or ("5119373") or ("5119366") or ("5107361") or ("5088089") or ("5050167") or ("4993019") or ("4977582") or ("4958341") or ("4942574") or ("4933930") or ("4933846") or ("4922486") or ("4912698") or ("4899333") or ("4897874") or ("4897834") or ("4896319") or ("4894824") or ("4893302") or ("4887266") or ("4875206") or ("4872160") or ("4872159") or ("4872158") or ("4872157") or ("4837786") or ("4777633") or ("4773065") or ("4768188") or ("4754452") or ("4736361") or ("4680753") or ("4679191") or ("4677612") or ("4672604") or ("4665518") or ("4656621") or ("4638477") or ("4633461") or ("4627051") or ("4606023") or ("4597077") or ("4581734") or ("4570257") or ("4564940") or ("4558180") or ("4555595") or ("4547879") or ("4538263") or ("4535448") or ("4485467") or ("4470140") or ("4455646") or ("4442502") or ("4430731") or ("4414663") or ("4406004") or ("4393491") or ("4387458") or ("4340961") or ("4150258") or ("4008378") or ("3740484") or ("3604936")).PN.	USPAT	2004/01/13 06:24

17	81	((timeslot time-slot (time adj slot)) same (assigning assigned assignment assign)) and ((("5243598") or ("5237563") or ("5223968") or ("5208808") or ("5200955") or ("5197064") or ("5195091") or ("5195090") or ("5189673") or ("5184347") or ("5179552") or ("5175537") or ("5166926") or ("5157654") or ("5142527") or ("5130984") or ("5124978") or ("5119373") or ("5119366") or ("5107361") or ("5088089") or ("5050167") or ("4993019") or ("4977582") or ("4958341") or ("4942574") or ("4933930") or ("4933846") or ("4922486") or ("4912698") or ("4899333") or ("4897874") or ("4897834") or ("4896319") or ("4894824") or ("4893302") or ("4887266") or ("4875206") or ("4872160") or ("4872159") or ("4872158") or ("4872157") or ("4837786") or ("4777633") or ("4773065") or ("4768188") or ("4754452") or ("4736361") or ("4680753") or ("4679191") or ("4677612") or ("4672604") or ("4665518") or ("4656621") or ("4638477") or ("4633461") or ("4627051") or ("4606023") or ("4597077") or ("4581734") or ("4570257") or ("4564940") or ("4558180") or ("4555595") or ("4547879") or ("4538263") or ("4535448") or ("4485467") or ("4470140") or ("4455646") or ("4442502") or ("4430731") or ("4414663") or ("4406004") or ("4393491") or ("4387458") or ("4340961") or ("4150258") or ("4008378") or ("3740484") or ("3604936")).PN.)	USPAT	2004/01/13 06:25
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19	47	(timeslot time-slot (time adj slot)) with (assigning assigned assignment assign) with statistic$5	USPAT	2004/01/13 07:24
20	13	(timeslot time-slot (time adj slot)) with (assigning assigned assignment assign) with (reclaim$5 reown re-own owner ownership regain$5 re-grain$5)	USPAT	2004/01/13 07:27
21	25	(timeslot time-slot (time adj slot)) with (assigning assigned assignment assign) with seiz$5	USPAT	2004/01/13 07:49
22	1	(timeslot time-slot (time adj slot)) with reclaim$5 with seiz$5	USPAT	2004/01/13 07:49
23	6	(timeslot time-slot (time adj slot)) with reclaim$5	USPAT	2004/01/13 10:16
24	299	(tdm or tdma timeslot time-slot (time adj slot)) with (reclaim$5 reus$5)	USPAT	2004/01/13 10:26
25	296	(tdm or tdma timeslot time-slot (time adj slot)) with (reclaim$5 reuse reusing reused)	USPAT	2004/01/13 10:17
26	161	((tdm or tdma timeslot time-slot (time adj slot)) with (reclaim$5 reuse reusing reused)) and @ad<=19970531	USPAT	2004/01/13 11:56
27	63	((tdm or tdma timeslot time-slot (time adj slot)) with (reclaim$5 reus$5)) and ((tdm or tdma timeslot time-slot (time adj slot)) adj assign$7)	USPAT	2004/01/13 10:54
28	1		USPAT	2004/01/13 10:28
29	5	(("3597549") or ("3647975") or ("3731002") or ("4063220") or ("4251880")).PN.	USPAT	2004/01/13 10:54

30	4	(tdm or tdma timeslot time-slot (time adj slot) slot) and ((("3597549") or ("3647975") or ("3731002") or ("4063220") or ("4251880")).PN.)	USPAT	2004/01/13 11:04
31	443	(tdm or tdma timeslot time-slot (time adj slot) slot) same aloha	USPAT	2004/01/13 11:05
32	96	(tdm or tdma timeslot time-slot (time adj slot) slot) same aloha same reservation	USPAT	2004/01/13 11:07
33	23	(tdm or tdma timeslot time-slot (time adj slot) slot) same aloha same reservation same dynamic$5	USPAT	2004/01/13 11:08
34	105	(tdm or tdma timeslot time-slot (time adj slot) slot) same reservation same dynamic$5	USPAT	2004/01/13 11:55
35	28	(tdm or tdma timeslot time-slot (time adj slot) slot) same owner$8 same dynamic$5	USPAT	2004/01/13 11:42
36	1	(time frequency) and 5121388.pn.	USPAT	2004/01/13 11:44
37	1	(identical "same" time frequency) and 5121388.pn.	USPAT	2004/01/13 11:49
38	1	(period interval) and 5121388.pn.	USPAT	2004/01/13 11:49
39	1	(identical "same" time frequency period interval assign$7) and 5107361.pn.	USPAT	2004/01/13 11:50
40	5162	(tdm or tdma timeslot time-slot (time adj slot) slot) same (busy idle)	USPAT	2004/01/13 11:55
41	898	((tdm or tdma timeslot time-slot (time adj slot) slot) same (busy idle)) and ((tdm or tdma timeslot time-slot (time adj slot) slot) adj (assigned assignment assign))	USPAT	2004/01/13 11:56
42	691	(((tdm or tdma timeslot time-slot (time adj slot) slot) same (busy idle)) and ((tdm or tdma timeslot time-slot (time adj slot) slot) adj (assigned assignment assign))) and @ad<=19970531	USPAT	2004/01/13 11:57
43	690	((tdm or tdma timeslot time-slot (time adj slot) slot) with (busy idle)) and ((tdm or tdma timeslot time-slot (time adj slot) slot) adj (assigned assignment assign))	USPAT	2004/01/13 11:57
44	542	(((tdm or tdma timeslot time-slot (time adj slot) slot) with (busy idle)) and ((tdm or tdma timeslot time-slot (time adj slot) slot) adj (assigned assignment assign))) and @ad<=19970531	USPAT	2004/01/13 11:57
45	193	((tdm or tdma timeslot time-slot (time adj slot) slot) with (busy idle) with (mark$4 indicat$6)) and ((tdm or tdma timeslot time-slot (time adj slot) slot) adj (assigned assignment assign))	USPAT	2004/01/13 14:06
46	165	(((tdm or tdma timeslot time-slot (time adj slot) slot) with (busy idle) with (mark$4 indicat$6)) and ((tdm or tdma timeslot time-slot (time adj slot) slot) adj (assigned assignment assign))) and @ad<=19970531	USPAT	2004/01/13 13:10
47	1	("5012469").PN.	USPAT	2004/01/13 11:58
48	1	assign$8 and 5012469.pn.	USPAT	2004/01/13 12:43
49	1	((period frequency length) and assign$8) and 5012469.pn.	USPAT	2004/01/13 12:46
50	1	((period frequency length) and assign$8) and 5107361.pn.	USPAT	2004/01/13 12:50
51	1	((period frequency length) and assign$8) and 4504946.pn.	USPAT	2004/01/13 12:56
52	1	(("same" equal identical$4) and assign$8) and 4504946.pn.	USPAT	2004/01/13 12:56
53	246	((tdm or tdma timeslot time-slot (time adj slot) slot) with (busy idle empty) with (mark$4 indicat$6)) and (period frequency length interval window) and ((tdm or tdma timeslot time-slot (time adj slot) slot) adj (assigned assignment assign))	USPAT	2004/01/13 13:11
54	207	(((tdm or tdma timeslot time-slot (time adj slot) slot) with (busy idle empty) with (mark$4 indicat$6)) and (period frequency length interval window) and ((tdm or tdma timeslot time-slot (time adj slot) slot) adj (assigned assignment assign))) and @ad<=19970531	USPAT	2004/01/13 13:10
55	199	((tdm or tdma timeslot time-slot (time adj slot) slot) with (busy idle empty) with (mark$4 indicat$6)) and ((period frequency length interval window) with (tdm or tdma timeslot time-slot (time adj slot) slot)) and ((tdm or tdma timeslot time-slot (time adj slot) slot) adj (assigned assignment assign))	USPAT	2004/01/13 14:00
56	3	(("5121388") or ("3755786") or ("4251880")).PN.	USPAT	2004/01/13 14:01

57	3	((tdm or tdma timeslot time-slot (time adj slot) slot) with (busy idle) with (mark$4 indicat$6)) and ((tdm or tdma timeslot time-slot (time adj slot) slot) with (assigned assignment assign)) with average	USPAT	2004/01/13 14:07
58	20	((tdm or tdma timeslot time-slot (time adj slot) slot) with (busy idle) with (mark$4 indicat$6)) and ((tdm or tdma timeslot time-slot (time adj slot) slot) with (assigned assignment assign)) with based	USPAT	2004/01/13 14:07

Citation

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1986 , Stowe, Vermont, United States

A two-bit contention-based TDMA technique for data transmissions

Authors
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ABSTRACT

The performance of a contention-based TDMA technique is studied in this paper. The frame structure of the time-axis is similar to [1] and [2]. The protocols proposed in [1],[2] and here are all active multiaccess techniques. The protocol in [1] is contention free and suitable for heavy traffic while a contention-based protocol suitable for light traffic is considered in [2]. The protocol to be studied in this paper is also contention in nature and performs considerably better than [2]. This

protocol is less complicated than [1] and out-performs [1] unless traffic is very high. Performance analyses, both transient and steady-state, have been successfully completed. Results obtained include average queue length and packet delay, etc. The validity of analysis is also verified by computer simulations.

↑ REFERENCES

Note: OCR errors may be found in this Reference List extracted from the full text article. ACM has opted to expose the complete List rather than only correct and linked references.

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↑ INDEX TERMS

Classification:

C. Computer Systems Organization

↳ **C.1** PROCESSOR ARCHITECTURES

↳ **C.2** COMPUTER-COMMUNICATION NETWORKS

↳ **C.2.2** Network Protocols

↳ **Nouns:** TDMA

General Terms:
Performance, Standardization

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DUAL-MODE SLOTTED TDMA DIGITAL BUS

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Abstract

A Dual-Mode Slotted TDMA Digital Bus has been designed and a prototype system has been built. This type of bus is a hybrid design which provides optimized bandwidth usage when such a system contains a combination of users with high duty cycle and/or synchronous data and low duty cycle asynchronous data. High duty cycle and/or synchronous users are assigned dedicated slots as in MITRIX. Low duty cycle asynchronous users are assigned a common set of contention slots as in slotted ALOHA. To assure both good response time and system stability, an algorithm was developed to compute an adaptive mean retransmission delay for the ALOHA slots. This paper discusses the theory behind the Dual-Mode Slotted TDMA Bus and provides supporting data determined by simulation.

I. INTRODUCTION

The growing use of distributed processing coupled with increasing terminal intelligence make imperative the need for improved solutions to the problems of computer-to-computer and computer-to-terminal communications.[1,2] The need exists to accommodate a wide variety of devices while maintaining full connectivity. Such devices may range from the largest main frames to minicomputers, terminals, and peripherals with differing speeds and protocols. The type of data to be transported may range from bursty and asynchronous to long, synchronous messages. The communication system supporting such a mix should be capable of good response time with reasonable capacity utilization. It should be flexible enough to meet the demands of growth, both in numbers of devices or subscribers and increasingly diverse types and complexities of subscribers.

The driving force behind the work described here is the requirement for a communication system for the following environment:

(a) a large number of terminals transmitting data in a very "bursty" or low duty cycle fashion;

(b) a small number of distributed processing elements consisting of large and small computers transmitting data at a higher duty cycle;

(c) a small number of devices exchanging synchronous data, e.g., facsimile or T1; and

(d) a high priority on full connectivity.

The full connectivity requirement for a large number of subscribers, i.e., the capability of any subscriber to communicate with any other subscriber or groups of subscribers simultaneously, leads either to a switching or bussing approach. This paper will deal exclusively with a dual-mode slotted time division multiple access (TDMA) bus implementation. The important performance parameters are response time and data capacity which interact to effect the efficiency and cost of the bus. The two modes interlaced on the bus are dedicated, assigned time slots and slotted ALOHA contention slots as discussed below. This system has been built as a prototype for proof of concept.

II. BACKGROUND

A TDMA system called MITRIX supported on dual CATV cable was reported by Willard.[3] Since a similar structure is utilized for the described work, an overview of MITRIX is appropriate at this point. Time is divided into intervals called slots and the slots are combined into larger intervals called frames. The subscribers are connected in parallel between inbound and outbound cables via a Bus Interface Unit (BIU) as shown in Figure 1. The transmitting subscriber transmits a message in assigned time slots on the inbound cable. This message is received by a Digital Bus Repeater (DBR) and retransmitted on the outbound cable. The receiving subscriber's BIU detects the address or data content and routes the message to the receiving subscriber.

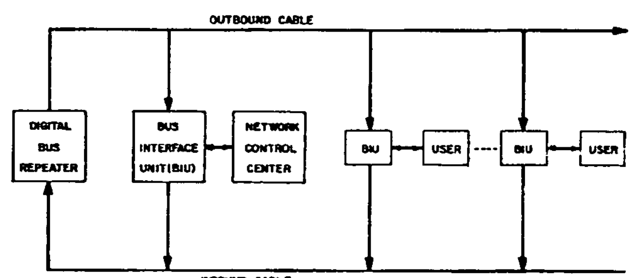

FIGURE 1. MITRIX BUS STRUCTURE

A Network Control Center (NCC) assigns slots uniquely to subscribers. This assignment consists of a starting slot and 2^N evenly spaced slots within a frame (N integral). Assignments are dynamically controlled by the NCC which responds to requests for service by subscribers. Service requests are made in slots dedicated for that purpose via slotted ALOHA style. It is important to note that the slot assignment granted by the NCC is unique for each subscriber, so no slots are shared and the slot assignment only changes on a logon-logoff basis.

Permanent or slowly changing slot assignments are not well matched to the requirements of bursty

users, i.e., a high data rate channel required for a short time. The more bursty the transmission, the less efficient will be the capacity utilization. The effect is to require a much greater transmission rate on the bus. Since each BIU must operate at the total bus rate and the BIU is the most replicated and, consequently, cost sensitive component in MITRIX, this drives up the total bus cost.

The dual-mode design addresses the poor capacity utilization versus response time trade off for bursty users having static slot assignments by using the slotted ALOHA technique. The general terminal and computer traffic in business and scientific environments exhibits bursty traffic statistics.[4] Hence, the relating of bursty requirements and statistical solutions like slotted ALOHA is timely and significant.

However, the static slot assignments are retained for those users who require synchronous data transmission. Having a slot with a fixed number of data bits arriving with precise regularity eases the task of reconstructing the synchronous data at the receiving end.[5]

III. DUAL-MODE SLOTTED TDMA BUS DESIGN

The dual-mode slotted TDMA bus was designed to accommodate asynchronous bursty, asynchronous high duty cycle, and synchronous users on the same channel with full connectivity. This is accomplished by assigning dedicated slots to the synchronous and very high duty cycle users in accordance with their relatively steady demand as in MITRIX and assigning a set of slots to be shared by the bursty users in the slotted ALOHA fashion. This is illustrated in Figure 2. All of the bursty users are given the same slot assignment creating an ALOHA slot periodically in the frame.

In the existing prototype system, the transmission rate is 7.373 Mbps and there are 16,384 slots per 0.8533 second frame. Each slot contains 384 bits; 128 header and 256 data. The nominal ALOHA slot assignment is every thirty-second slot or 512 slots per frame.

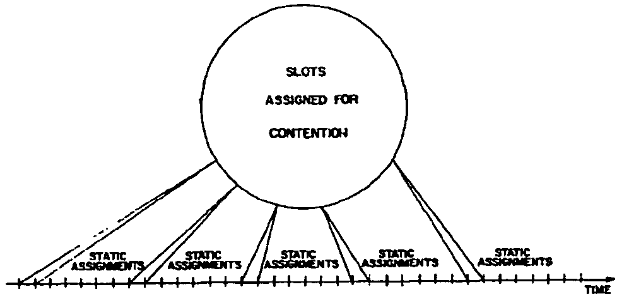

FIGURE 2. DUAL MODE SLOTTED TDMA SLOT STRUCTURE

The operation of this ALOHA subchannel has been investigated by a number of researchers.[6,7,8] Figure 3 shows an equilibrium locus for retransmission probability, p = .0018, which is a plot of

$$S_{out} = (1-p)^n S e^{-S} + np\,(1-p)^{n-1} e^{-S} \qquad (1)$$

where n = number of users in the queued state, i.e., number of users having suffered collisions who are trying to retransmit;

p = the probability of retransmission in a slot;

S_{out} = throughput or fraction of time that the channel is engaged in a successful transmission; and

S = user arrival rate in offered slots per slot set equal to S_{out} for the equilibrium locus.

Superimposed on the equilibrium locus is a load line for the system defined at equilibrium as

$$(M - n)\sigma = S_{out} \qquad (2)$$

where M = total number of users; and

σ = probability of a message arrival from a user not currently in the queued state.

This equilibrium locus and load line combination in Figure 3 represents a stable slotted ALOHA design as shown by Kleinrock and Lam.[8]

The load line is drawn for 3200 users with a 9600 bps data rate and 0.0002 transmission duty cycle. The users transmit an aggregate of 98 slots per second with each slot containing an average of 63 bits of data. The throughput intersection of 0.163 comes from (98 slots/second) (0.8533 seconds/frame)/(512 ALOHA slots/frame). The approximate mean response time is determined by the application of Little's Result[9] at the intersection point $n_0/S_0 = 20/0.163 = 123$ slots = 0.2 seconds. Response time is defined as the time from an attempt to transmit to the successful completion of the transmission.

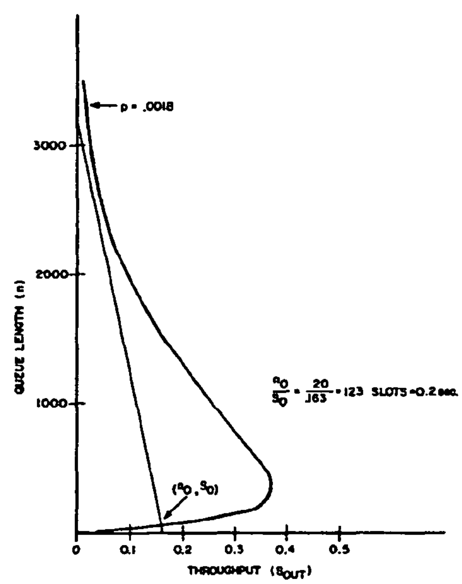

FIGURE 3. SLOTTED ALOHA DESIGN CURVE

It is expected that this performance can be improved further by changing the retransmission probability as a function of the number of queued users.(10,11) Specifically, if we differentiate equation (1) with respect to p and set the derivative equal to zero, we find that the maximum throughput exists when

$$p = \frac{1 - S}{n - S} \tag{3}$$

Equation (3) represents the optimal control strategy for a slotted ALOHA system in which the instantaneous values of queue length, n, and throughput, S, are known. To implement this strategy, we divide time into windows. We assign a value p* for the next window, where

$$p^* = \frac{1 - S}{\bar{n} - S} \tag{4}$$

where $\bar{n}$ is the average value of n over the previous window.

The resultant contention system can be considered as a time series of fixed retransmission probability, slotted ALOHA equilibrium loci, each prevailing for one window. The fixed mean retransmission delay is updated for each window in accordance with an estimate of $\bar{n}$ from the previous window. If $\bar{n}$ was estimated to be large, the retransmission delay will be set high by setting p low. Similarly, if $\bar{n}$ was estimated to be small, p will be set high with resultant small retransmission delay. This is similar to the optimization procedure investigated by Lam and Kleinrock(10) where p was to be one of two values, one high enough to insure stability and one low enough to yield good response time when the backlog is not large.

The estimate of $\bar{n}$ is obtained as follows.

Let us assume that n is slowly varying over the duration of a window of length x slots. The average value of n over these x slots is $\bar{n}$. Also assume that the value of S is fixed. We will discuss the implications of these assumptions after the derivation.

There are three conditions in which a slot can be found: empty, successful packet transmission, or collision of two or more packets. The probability of the slot being empty, P_E, is the product of the probability of no user arrivals and the probability of no arrivals from the queue.

Hence,

$$P_E = (1-p)^{\bar{n}} e^{-S} \tag{5}$$

Given that there are x slots, each having a probability, P_E, of being empty and there are ϕ slots in that window which are empty, the distribution of ϕ is binominal and the mean of this distribution is

$$\phi = xP_E \tag{6}$$

Using this result in equation (5) yields

$$\frac{\phi}{x} = (1-p)^{\bar{n}} e^{-S} \tag{7}$$

Combining this with equation (2), and solving for $\bar{n}$ we get

$$\bar{n} \cong \frac{\ln\left(\frac{\phi}{x}\right) + M\sigma}{\sigma - p} \tag{8}$$

where $-p \cong \ln(1-p)$ for $p << 1$

Hence, given the fraction of empty slots in the window, the total number of users, the probability of arrival of a user, and the current probability of retransmission, the average number in the queue over tha window can be estimated. This result can be used in equation (4) to set the probability of retransmission for the next window.

It is obvious that at any given instant, the estimate of $\bar{n}$ and S will be incorrect. Estimates of $\bar{n}$ greater than the actual queue length show a slight decrease in performance, while estimates of $\bar{n}$ less than the actual queue length can lead to stability problems. This is illustrated in Figure 4 in which equilibrium loci are plotted for a perfect estimate and for errors in the estimate. It is obvious that grossly high estimates of queue length yield only mild deterioration of the throughput and, consequently, response time. However, very low estimates of queue length yield conditions which deteriorate rapidly to zero throughput and large queue situations.

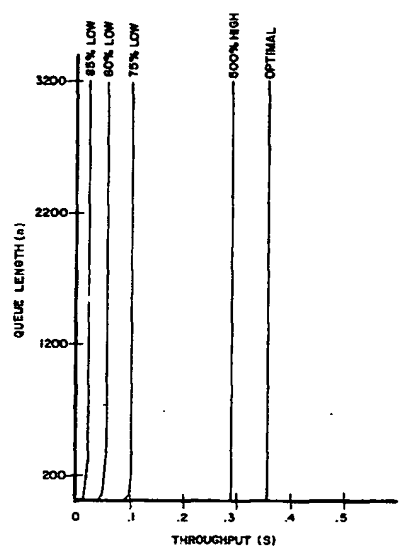

FIGURE 4. ADAPTIVE RETRANSMISSION PERFORMANCE WITH OPTIMAL AND INCORRECT ESTIMATES OF n.

We use this result in a conservative fashion by setting p* to the minimum predetermined value whenever $\phi/x \leq 0.1$. This minimum value is selected by establishing a stable slotted ALOHA system for the given load line assuming a fixed retransmission probability. This is equivalent to estimating $\bar{n}$ high when the system is busy. This also protects against system breakdown when $\bar{n}$ does not conform to the assumption of being slowly varying.

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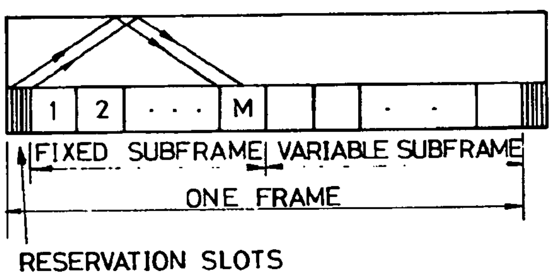

Fig. 1. Frame structure of the protocol considered in [1]

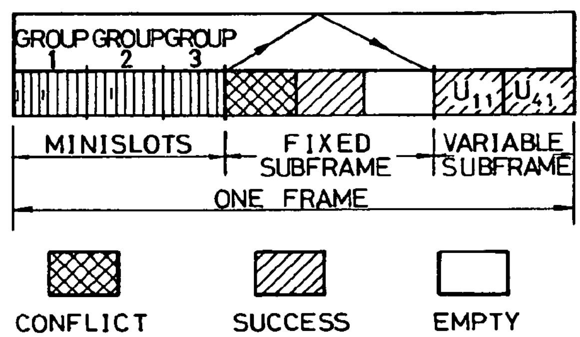

Fig. 2. Frame structure of the protocol considered in [2]

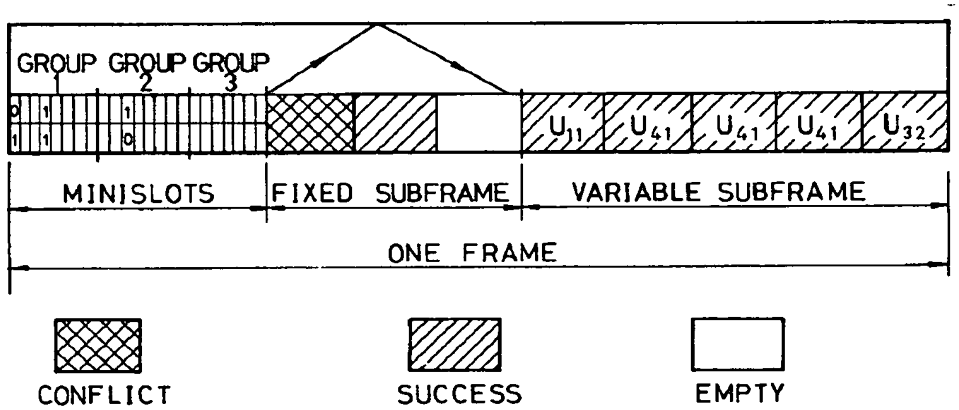

Fig. 3. Frame structure of the protocol considered in this paper

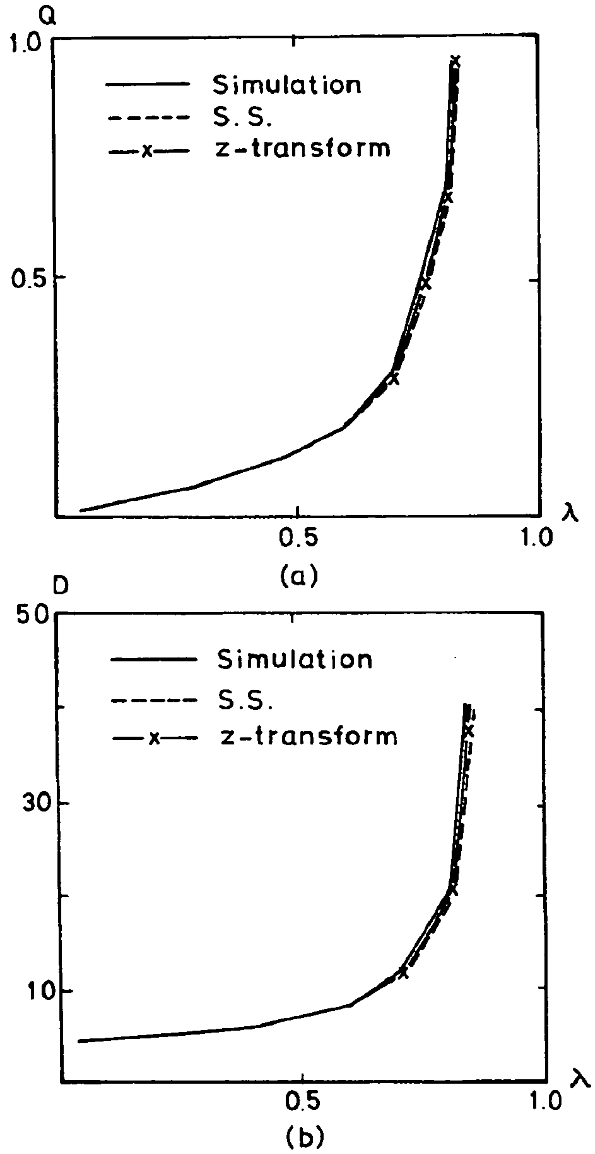

Fig. 4. Q and D vs λ for a system with M = 20

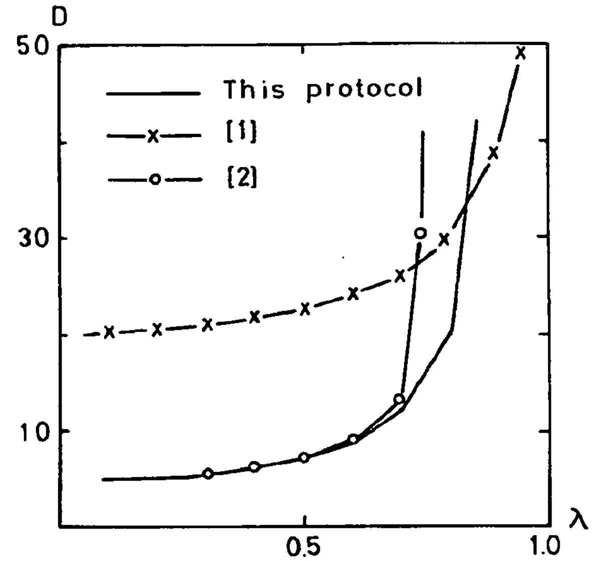

Fig. 5. Comparison between the present protocol and [1], [2]

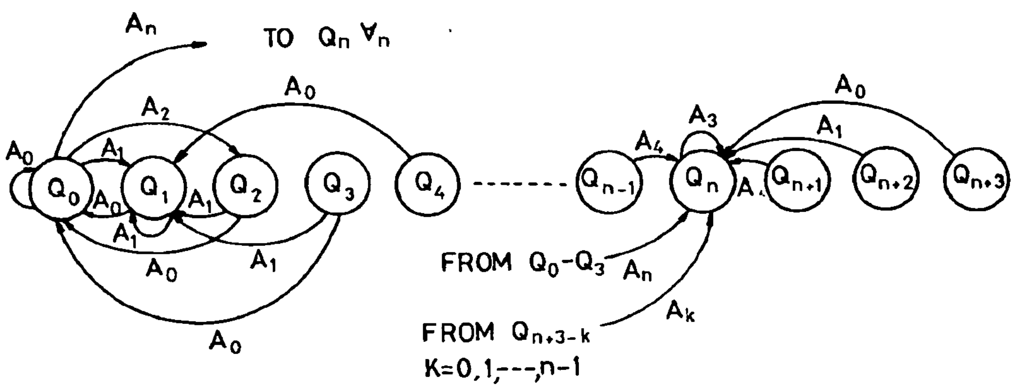

Fig. 6. State diagram of $Q^b_{i,j}$